
5 Aggregate Production

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- Drilling and Blasting*
- Shot Rock or Gravel Bank*

Crushing

- Scalping*
- Primary Crushing*
- Secondary and Tertiary Crushing*
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Stockpiling - General

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CHAPTER FIVE:

AGGREGATE PRODUCTION

This chapter discusses the total process of aggregate production from extraction through processing. It also covers subsequent handling, stockpiling, and shipping of the product up to the point where it leaves the producer's control. However, methods of production that may be desirable to achieve balances of productivity, economy, and product conformity under various conditions are not covered. Actual techniques for production that are optimum for given conditions are best learned in the many seminars, training courses, and publications available. One excellent reference is "The Aggregate Handbook," published by the National Stone Association (1991). Processing influences mineral quality and integrity, aggregate physical properties, and, in particular, gradation (size control). Establishing a stable production process can reduce variability of the product.

Extraction Influences on Quality

STRIPPING

Not clean enough
Spillage over mining face

DRILLING AND BLASTING

Hole size, depth, and spacing (pattern)
Blast delay sequence
Blast intensity or charge

SHOTROCK OR GRAVEL BANK

Non-uniform load-out
Equipment changes
Geologic variability
Moisture variability in shotrock
Above/below-water gravel deposits

EXTRACTION

With the exception of slag and other manufactured aggregates most materials for aggregate production come from bedrock or unconsolidated deposits. The vast majority of materials used in the mineral aggregate industry are obtained from surface-mined stone quarries or from sand and gravel pits. How materials are extracted influences their quality.

STRIPPING

As a first step, a company should spell out a detailed stripping procedure for each and every deposit it mines. This phase often is overlooked, yet it has a great influence on the quality and variability of the product. Inadequate removal of overburden from the mineral deposit often can be the source of excessive variation in minus No. 200 material; it may even have a deleterious affect on nearby vegetation and other aspects of the mine.

For example, excessive knobs and depressions on the surface of a stone



deposit may necessitate the use of smaller equipment or special techniques to clean the stone. Inexperienced equipment operators can easily corrupt good stripping practices (which are somewhat of an art and site specific). Spillage over the working face and other sloppy practices can also affect the cleaning process. Both surface cleanliness and spillage are influenced by employee attitude. Good management practice can nearly eliminate both problems.

Figure 5-1. Stripping.

DRILLING AND BLASTING

Quarry operators commonly design fragmentation shots for safety, economy, ease of use at the primary crusher, and even public relations, but they often forget about quality.

It is important that the shot layout be properly engineered, documented, and adhered to for maximum consistency. Varying the shot pattern can mean changes in product size throughout the operation. Smaller shot rock, resulting in less crushing in the secondary and tertiary stages, may mean less

improvement through crushing. Therefore the mineral quality and/or changes in physical properties of the product may be affected.



Figure 5-2. Drilling.

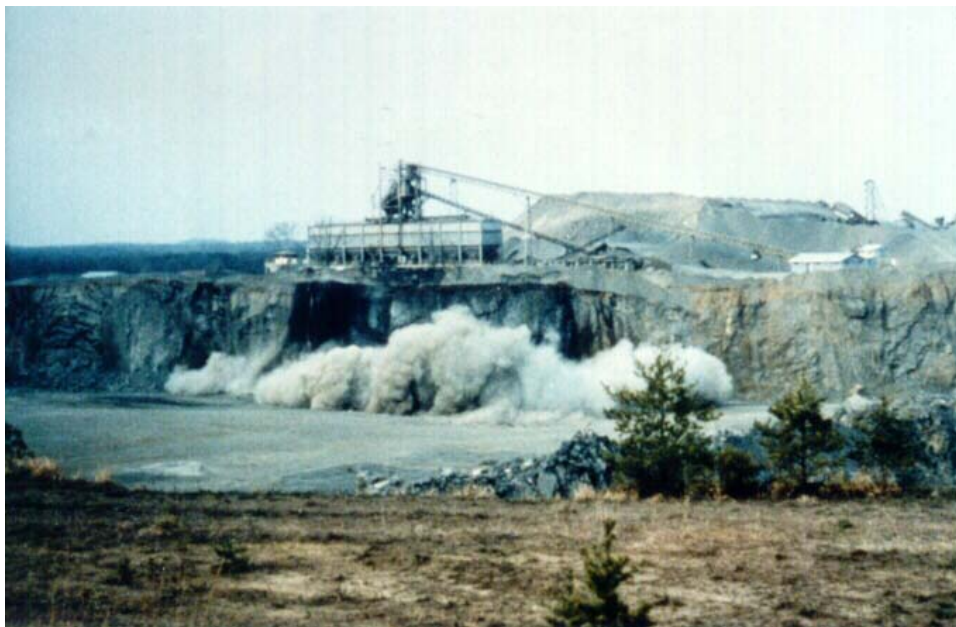


Figure 5-3. Blast or shot.

Hole detonation-sequencing and blast intensity also must be properly engineered. Size changes resulting from inattention to detail can have the same effects as mentioned above. Also, an erratic blast that throws the shot

rock over a large area will tend to cause variation in size gradation that is delivered to the primary crusher. Any deviation from previously established shot patterns, sequencing, and intensity should be carefully thought out as to the effect on product quality. Production changes should be documented in the producer's Quality Control Plan and notification should be given to INDOT.

SHOT ROCK OR GRAVEL BANK

A constant problem of gravel pit and quarry operators is the difficulty in maintaining uniform load-out from either the shot rock pile or the gravel bank. Even the best shot will have some variation from side to side and from front to back. Only experienced and well-trained equipment operators can accomplish the mixing from around the shot for the most uniform feed to the processing plant.

Subsurface sampling and testing are needed to inform gravel-pit managers where the size of the material changes. In many cases, for example, material from both above and below ground water level must be blended in a prescribed manner to maintain uniform feed to the plant.

Changes in equipment, if done without thought as to how to maintain uniform sizing, also may have the same effect. Any change in equipment must be evaluated for effect. These changes are incorporated into an addenda to the producer's Quality Control Plan.



Figure 5-4. Loading quarry truck.



Figure 5-5. Sand and gravel excavation.

Geologic variability in the deposit can sometimes affect sizing but more often will cause a change in mineral integrity and physical properties. If a large variation exists it may necessitate separating some products at later stages in the process. In the case of geologic variability, communications with the customer and also with INDOT are crucial.

Moisture variation in shot rock can also cause significant problems during processing. It is important that shot-rock moisture be monitored because significant changes will almost always require changes in downstream processing.

CRUSHING

The first steps of processing begins after the extraction from quarry or pit. Many of these steps also are common to recycled materials, clay, and other manufactured aggregates. The first stage in most operations is the reduction and sizing by crushing. Some operations, however, provide a step prior to crushing called scalping.



Figure 5-6. Scalping.

SCALPING

Scalping most often is used to divert fines at a jaw primary crusher in order to improve crusher efficiency. In this way the very coarse portion is crushed and then recombined with the portion of crusher-run material before further processing. This first step may, however, be an excellent time to deal with a deleterious problem. If a deleterious or fines problem exists in the finer fraction of crusher-run material (namely, clay, shale, finely weathered material, etc.) the fall-through of the scalping operation may be totally or partially diverted and wasted, or it may be made into a product of lesser quality. In any case only acceptable amounts, if any, should be returned back into the higher quality product. Consideration of process variables in this early stage can be very important!

PRIMARY CRUSHING

In stone quarries or in very "boney" gravel pits, large material usually is reduced in size by either a jaw or a gyratory crusher.

Both types are compression crushers. Although economical, they have the tendency to create thin, elongated particles. Particle shapes sometimes can be a problem for customers, especially producers of hot mix asphalt. Particle shape operations will be discussed later in this chapter. In some operations impact crushers are used for primary crushing, but they may have a slightly higher cost per ton. Impact crushers can upgrade poor-quality aggregate and increase separation, such as removal of rebar from concrete in recycling operations.

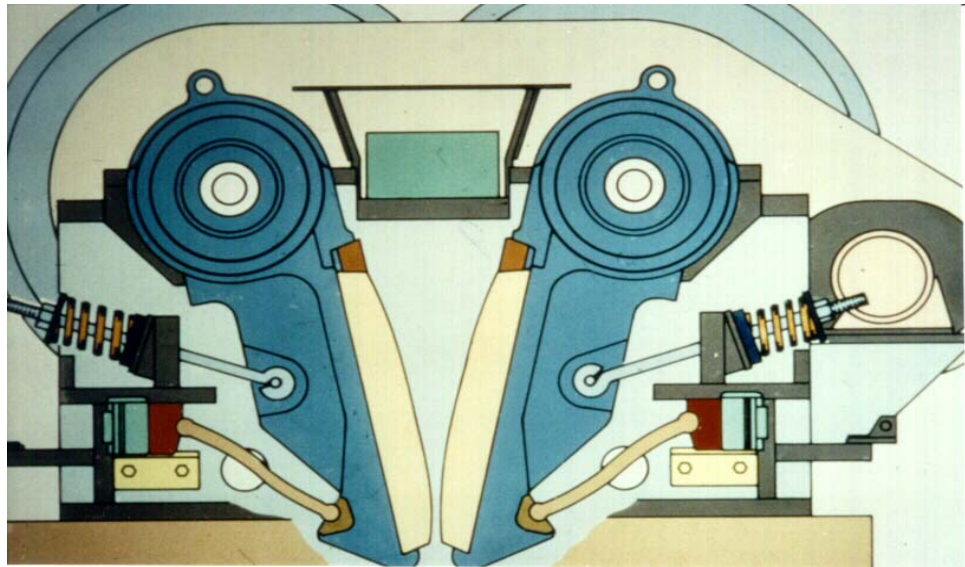


Figure 5-7. Sectional view of jaw crusher.

After primary crushing/reduction the resulting aggregate generally will be placed in a large "surge" pile where it can be fed into the secondary operation whenever convenient.

Care always must be taken when building up and loading out surge piles, as this step can be a major source of segregation of material going to the secondary plant. Variation at this point may affect both mineral quality and gradation. Drawing from an inverted cone over a load-out tunnel works well after material has been deposited and left undisturbed to form the walls of the draw-down cone. If the need ever arises to consume the entire pile,



Figure 5-8. Surge pile.

care should be taken to thoroughly mix the older material a little at a time with fresh product to make the surge as uniform as possible as it is being pushed into the tunnel. If the operation relies on end loaders to feed the secondary plant from the surge pile the same care should be taken to mix coarse with fine material from the outside to the inside of the pile (loading out of various shaped stockpiles will be covered later).

SECONDARY AND TERTIARY CRUSHING

Secondary and tertiary crushing, if necessary, are the final steps in reducing the material to a desired product size. Historically, cone and roll crushers were the most common choice crushers, but in recent years impact crushers are more widely used. These crushers also are sometimes used as primary crushers for fine-grained gravel deposits.

The cone crusher (a compression type) simply squashes the aggregate between the oscillating cone and the crusher wall. Clearance settings on this equipment must be checked and maintained as part of standard operating procedure.

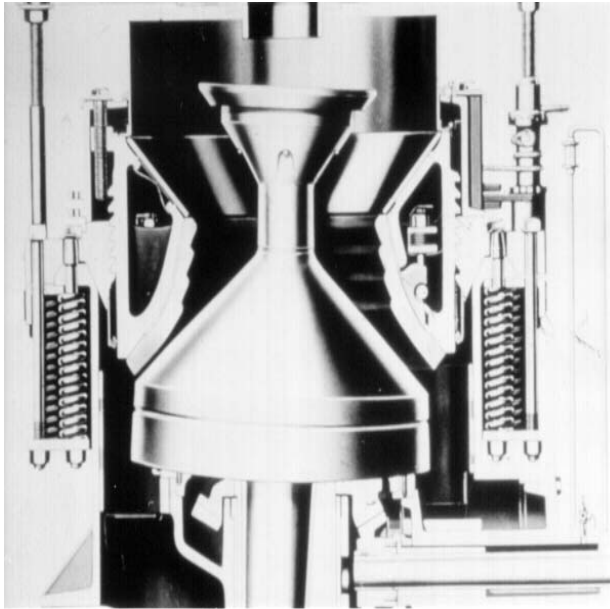


Figure 5-9. Cone crusher.

As with other compression crushers, the cone crusher will yield a somewhat elongated and slivery particle shape. This can be minimized, however, by "choke" feeding the crusher. This technique will also make the shape and size more uniform. One way to choke feed is with a surge hopper and a controlled belt-feed to the cone crusher; automatic level controls measure the head of the material over the top of the cone.



Figure 5-10. Crusher feed system.

Roll crushers, another compression type, simply break the material by pinching. They are often found in gravel operations.

Roller crushers have constant maintenance problems and are prone to excessive wear. The rollers must be checked frequently to insure proper clearance and uniformity across each roller. Rebuilding and remilling the roller should be a standard operating procedure.

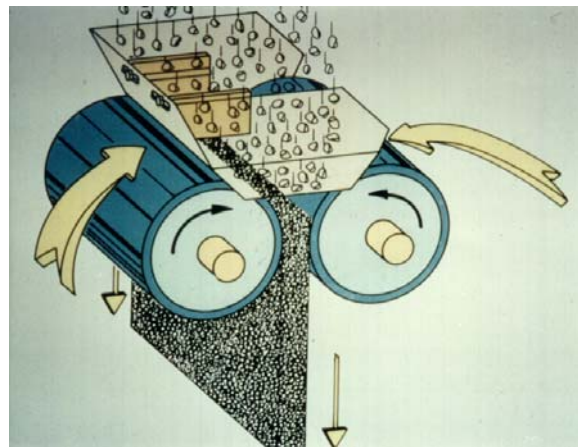


Figure 5-11. Roller crusher.

IMPACT CRUSHING

Impact crushers may be used as primary, secondary, or tertiary crushers. Despite having a somewhat higher operating cost than other crushers, they tend to produce a more uniform particle shape. Impact crushers usually will benefit the aggregate better than compression crushers, and they may generate more fines. Common types are the horizontal shaft, vertical shaft, and hammermill impactors.

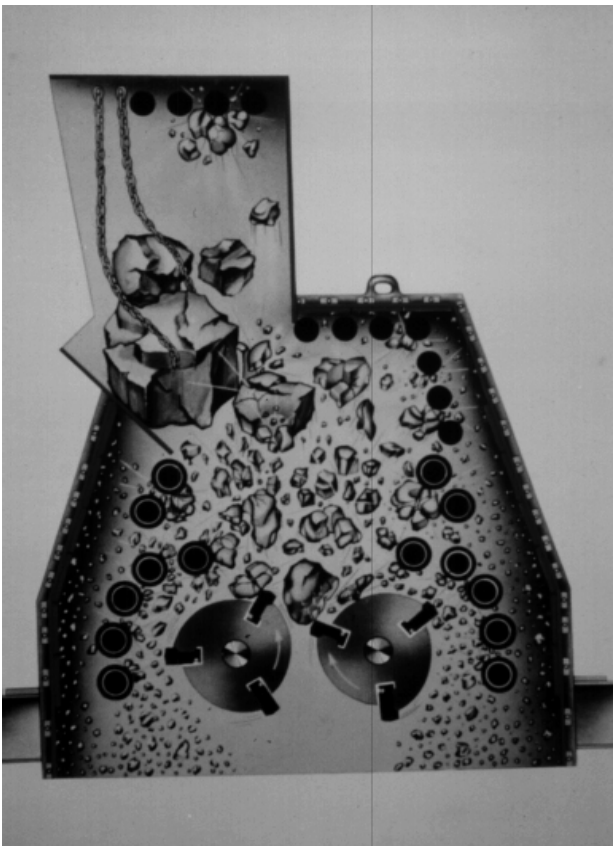


Figure 5-12. Horizontal shaft impactor.

The horizontal shaft single or double rotor can aggressively handle large and odd-shaped material. Large horizontal impactors sometimes are used as primary crushers. Fracturing occurs at the same time by rock against rotor, rock against breaker bar, and rock on rock.

The vertical shaft impactor is operated in two modes: 1) rock against anvil, or 2) rock against rock (through the installation of a rock shelf). The producer must decide carefully the mode best suited to the raw material.

The hammermill impactor provides excellent reduction and beneficiation through the impacting and shearing action of the hammers and grates. The user should be prepared to deal with the generation of a large amount of fines. This type of crusher is sometimes used in the manufacture of agricultural ground limestone.

OTHER BENEFACATION

Other forms of benefaction for quality are available to the producer; important types are the log washer, heavy media separator, and attrition mill.

The log washer commonly is used in wet operations to agitate and scrub clay and other objectionable fines from coarse aggregate. A producer may need to use a log washer when rinsing screens will not do the job.

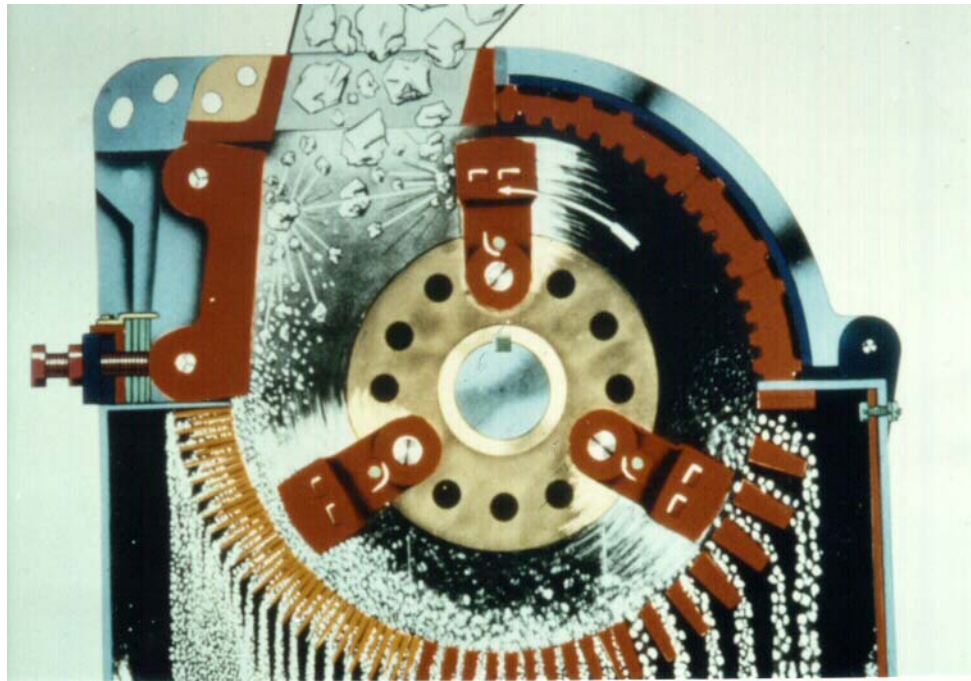


Figure 5-13. Hammermill

Heavy media separation is somewhat costly, but may be the only practical way for a producer to meet quality requirements. This method will work only when the undesirable material has a different specific gravity than the desirable material. The deleterious material is discarded after the media is separated for recycling.

Attrition mills are seldom used but remain an option when the deleterious particles are uniformly softer than the non-deleterious particles. The attrition mill abrades the deleterious particles into fines that can be screened out of the system.

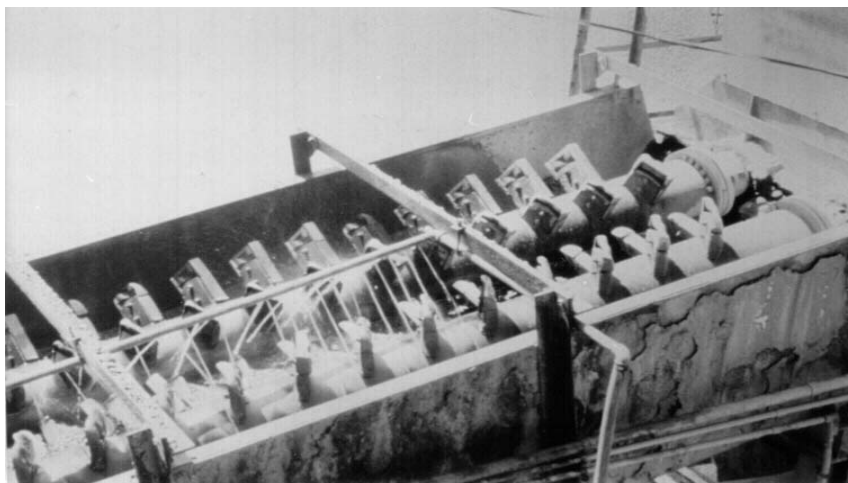


Figure 5-14. Log washer

SCREENING

Screening is another technique to control both quality and gradation of the aggregate product.

PRODUCT QUALITY

If deleterious material still exists at undesirable levels after crushing and can be identified as being predominantly in one size range that is not needed for product size, it may be screened out (namely, fines or top size). This step may occur between crushings so that an opportunity exists to recreate the same size downstream, if needed, to create a product. The screened-out lower-quality material may be used for a lower quality product or wasted if no use exists.

The rinse screen is also commonly used. By running the material over a screen that retains all the product it is often possible to rinse away enough clay and deleterious fines to render the product acceptable.



Figure 5-15. Rinse screens.

GRADATION CONTROL

The best technique for gradation control is screening. Screening can be done wet or dry, depending on the kind of aggregate being processed and the degree of consistency needed for each product.

Washing, for example, may be necessary to clean a concrete aggregate, but it may not be needed for hot mix asphalt products, which can contain more fines. For gradation control alone, however, a producer may come to realize that gradation consistency can only be maintained by using wet screening, especially for the hot mix asphalt products. Gradation consistency is usually an overriding factor for a hot mix asphalt customer. Water volume and flow direction are critical in wet screening. Frequent checking of gradation should be a standard operating procedure.

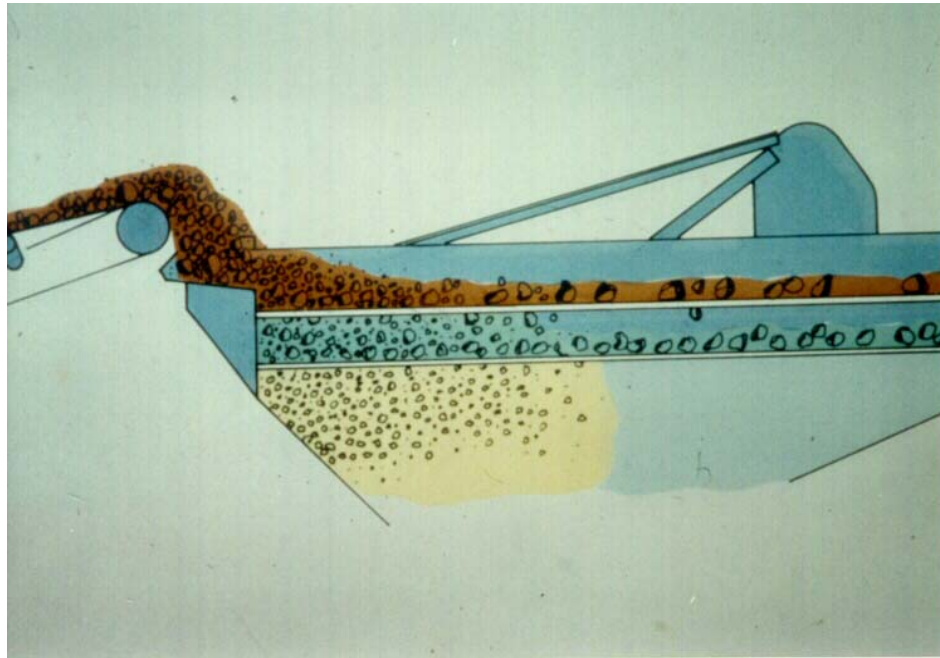


Figure 5-16. Screening.

Dry screening is a slight misnomer because the material passing over the screen decks is wet, ranging from slightly damp to very wet, depending on conditions such as rain or subsurface moisture; non-washed screening is a more accurate description. High moisture is the nemesis of non-washed screening because it can cause some material to become sticky and bind together, making it harder to separate. Furthermore, high-moisture conditions may cause binding of lower screen decks, causing override of the material rather than separation. If these conditions are encountered, the producer may need to establish a balance between the moisture content of the incoming material and the feed rate through the screens. This balance may need to be made for each hour of operation. If reduced feed rates do not solve the problem or if it becomes too costly, washing or an additional screen area may be needed.

Sometimes screening variation is too great even under the most favorable of conditions. When this occurs the producer must first check that the equipment and the screen cloth are in good repair. The most common reason for high screening variability is the tendency to push too much material over a screen. The only way to maintain a bed of material thin enough for optimum efficiency is to provide enough screening to allow the desired rate of production. Standard operating procedures should reflect the maximum feed rate for the design of the plant.

For well-graded products having many sieves, (namely, #53s) gradation control may not be accomplished without first separating the material into fractions. Separating the material into numerous small fractions and then back-blending at a set rate for each fraction may be necessary to control the gradation.

Frequent sampling, testing, and control charting are necessary for monitoring, because aggregate gradation is subject to so many variables.

SAND PRODUCTION

Sand plays a critical role as a construction aggregate and it deserves special attention when considering the means of process control. Unlike coarse aggregate where various types of crushers can be used to upgrade mineral quality, sand basically relies on the same techniques to address both mineral quality and sizing. These techniques are called particle exclusion. Whichever size the producer decides to eliminate for quality reasons obviously also will affect sizing.

NATURAL SAND

Good quality natural sand is readily available in many areas and may be easy to obtain and process. As with the gravels that they often accompany, the sand deposits may not have been laid uniformly, meaning a potential change in quality and size is possible. In some deposits, sand found below the water table differs in fines content and quality from that found above the water table. Subsurface drilling, sampling, and testing is necessary to know to what degree and where these differences occur. Standard operating procedures in the Quality Control Plan should address the process if differences in size and quality are encountered, as a uniformly graded product of predictable quality must be maintained.

MANUFACTURED SAND

Because of its angularity, manufactured sand is becoming more popular, especially for use in hot mix asphalt where stability is increasingly more critical. Many Indiana quarries are high in clay content and often a large amount of dust ends up in the feed stock for manufactured sand. Care must be taken to select the appropriate classification equipment that will remove the necessary amount of minus No. 200, yet retain other fractions of the sand gradation that are needed. For some uses particle shape is important. Particle shape is set primarily by the crushing operation for the coarse aggregate. It should be remembered that any changes in crushers or crushing techniques may affect the properties of the manufactured sand product and therefore affect the customer's use of the product.

PROCESSING

Very few sand products are produced by air classification or by direct nonwashed screening. Most sands are produced with wash water and water classification. The key to all rinsing and water classifying systems is adequate delivery of water. Inadequate water supply and poor maintenance are the two most common reasons for inconsistent sand gradations.

The most common water classifier is a simple dewatering screw which can make a single "cut" in gradation and float out a certain amount of fines. By altering the through-put and rate of water flow the "cut" point can be changed.

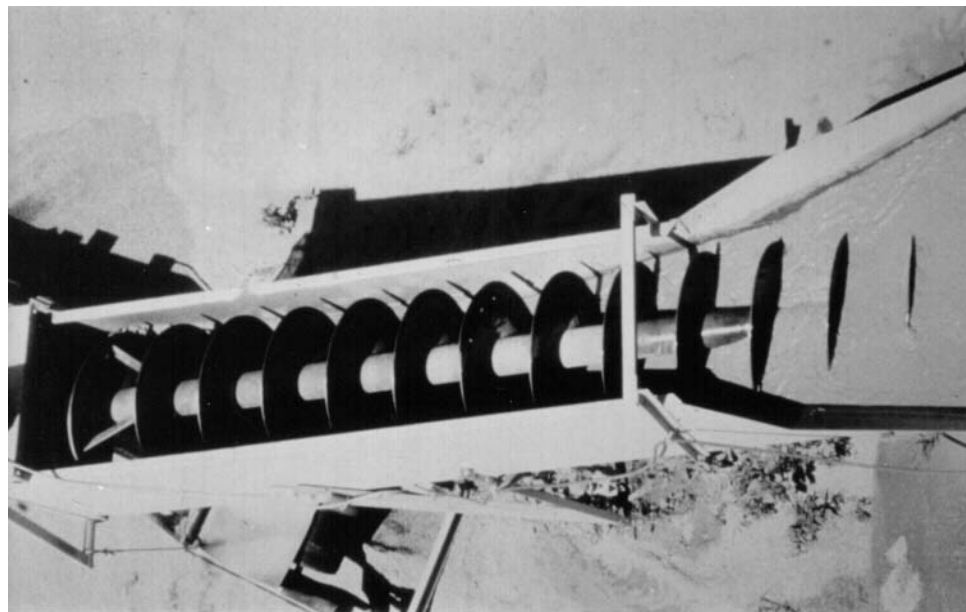


Figure 5-17. Dewatering screw.

A variation of the dewatering screw is the dewatering wheel. This device also is capable only of making a "cut" in the feed stock but can be more finely tuned and may be the better choice when trying to retain as much No. 50 and No. 100 material as possible.



Figure 5-18. Dewatering wheel.

An even more sensitive method of cutting out fines is the wet cyclone. The sand slurry in the cyclone is spun at a prescribed velocity; centrifugal force separates the coarser fraction from the water and fines which exit to the pond.



Figure 5-19. Wet cyclone.

Any of these techniques could conceivably be used with others in tandem or in tandem with rinse screens. The material could then be back-blended to create a desired product. A simpler and probably more cost effective way to control a sand gradation on multiple sieves would be the rising current, multiple cell classifier. Here numerous cells, each having varying water pressures, select different sizes of material. Any number of cells can then be combined to create the final product. With this type of system a high degree of process control is possible. It is very important to write exact standard operating procedures for each product and make those part of the Quality Control Plan.

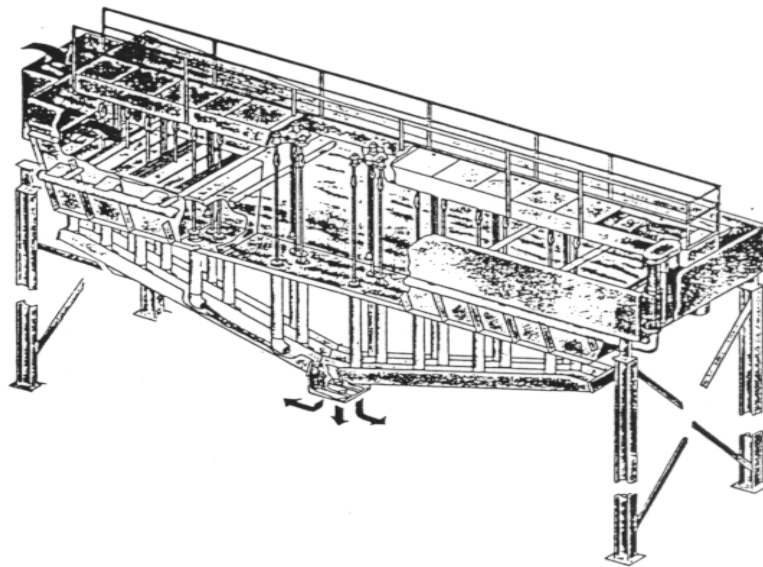


Figure 5-20. Multiple cell classifier.

SEGREGATION

Controlling the production process should be given first consideration when beginning on the road to quality. It is here that all the inputs are measured, evaluated, and controlled so that product conformity and uniformity can be predicted. We often feel that when a uniform product appears on the last belt our jobs are finished, but usually that is far from true. Whenever one rock is placed upon another, segregation can destroy the uniformity that the producer so carefully built into the product.

Actually, segregation begins on the belt where fines vibrate to the bottom and coarse aggregate remains on top as the material bounces across the idlers. At the end of the belt, if left undeflected, the coarse particles are thrown out and away. Fine particles, on the other hand, tend to drop down or if wet will even follow back underneath the conveyor. The greater the

speed of the belt, the worse the segregation problem. This is known as front-to-back segregation and can be addressed by the following methods:

1. Belt wipers underneath the head pulley will reduce carry back.
2. Movable stackers kept near the top of the pile reduces the spread.
3. Mixing paddles or deflectors at the head pulley will tend to keep the material together.
4. Wider belts at lower velocities prevent segregation.

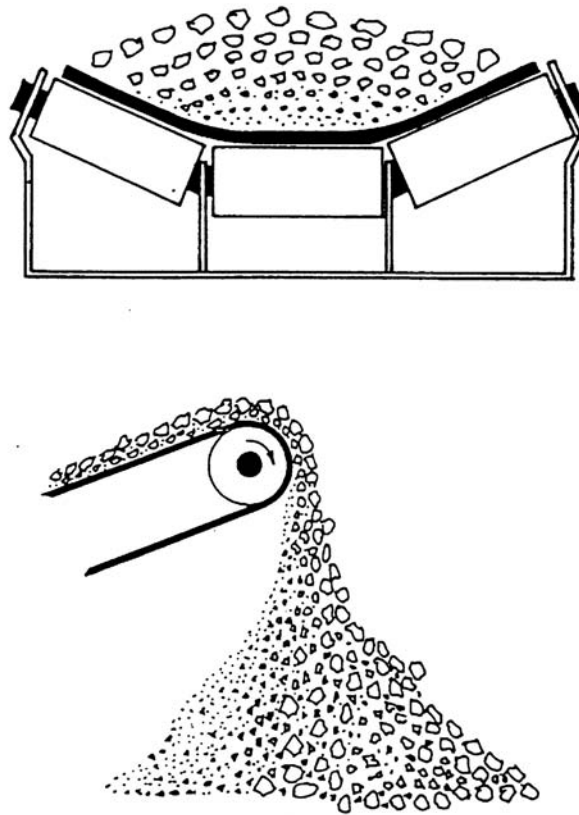


Figure 5-21. Belt segregation.



Figure 5-22. Adjustable conveyor with mixing paddle.

A second common type of segregation is "roll down," which occurs any time aggregate is piled so that large particles roll down the sloped side of the pile. The higher the pile, the worse this problem. This type of segregation is very obvious in operations with high conical stockpiles, but also occurs in improperly loaded trucks. Keeping storage bins over half-full whenever possible will improve the situation.

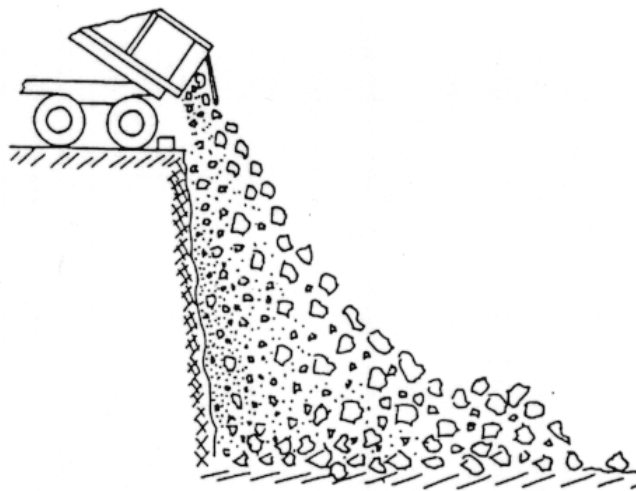


Figure 5-23. End dump segregation.

STOCKPILING AND HANDLING

Segregation is probably the greatest nemesis of stockpiling and handling, but certainly other problems such as degradation and contamination can adversely affect product quality. Every possible precaution should be taken to protect product quality from the point of manufacture to the point where it leaves the producer's control.

CONE STOCKPILES

Although the cone stockpile is very common in the aggregate industry, it can easily reduce product integrity. Roll-down segregation obviously occurs in full circle around the pile, and very high piles make it virtually impossible to adequately remix the material before shipping. These piles usually are being replenished with fresh material as old and new material is being removed, which keeps the product size in a state of continual change.



Figure 5-24. Material added to cone.

In some cases the "front-to-back" segregation adds extra coarse material thrown forward and extra fines carried back for even greater variability. In addition, some piles are not fully retrieved for several years and the new product that is added to the old pile may even have different production targets. Situations like these add up to serious problems for predicting gradation uniformity in the retrieved product.



Figure 5-25. Comingled cone piles.

The final element of a cone pile that adds to the effects of both the roll-down and front-to-back phenomena is excessively high drop from the end of a fixed conveyor to the top of the pile. This must be avoided. Use of cone stockpiles should be kept to a minimum and used with extreme caution.



Figure 5-26. High conveyor drop.

RADIAL STOCKPILES

A radial stacker is a compromise solution for conveyor-built stockpiles, especially if kept less than 20 feet. The proper technique is to keep the end of the movable conveyor less than a meter from the top of the pile and raise the conveyor with the pile to its full height. Then the conveyor should be moved horizontally with the pile in small increments. In this manner the pile is constructed at one end while the products are retrieved at the other end.



Figure 5-27. Radial stockpile.

Although roll-down segregation does occur from the sides of the pile, a continual remixing of coarse and fine material occurs longitudinally as the pile advances. Proper retrieval can take care of the edges.

TRUCK BUILT STOCKPILES

If piles from the end of the product belts are thoroughly remixed then truck-built stockpiles are capable of greatly minimizing segregation, if the trucks are loaded properly. The best truck-built stockpiles are those that are constructed one dump high with each dump placed against previously



dumped material. Here, because of the low profile, roll-down segregation is minimal and can be reduced by reasonable remixing effort during load out. However these stockpiles require more space than the others mentioned. A technique that can help reduce the required area is to restock some

Figure 5-28. Low profile truck stockpiles.

dumps on top of other dumps with a large endloader operating from ground level. In this case, care should be taken to place the upper lift back from the edge far enough that a long sloped face is not created that would cause the same kind of roll-down problem that this type of pile is meant to eliminate.

LAYERED STOCKPILES

A layered stockpile, if built correctly, can also greatly minimize segregation. Unfortunately they are very difficult to build properly. Each layer is placed uniformly across the top of the pile in thin horizontal lifts. Care should be taken to keep the edge of each new lift set back from the edge of each previous lift so as not to create long sloped edges. This is best done with a large clam shell crane, which is slow and tedious, or with specially made equipment that can place the layers without being on the pile. A compromise is to allow hauling equipment on top of the pile. However, this will cause degradation of the product, and the pushing equipment may move the material over the edges causing severe segregation. Generally, these activities are poorly managed, and the stockpile takes on the shape of a ramp and spills over. These situations are very detrimental to product quality.

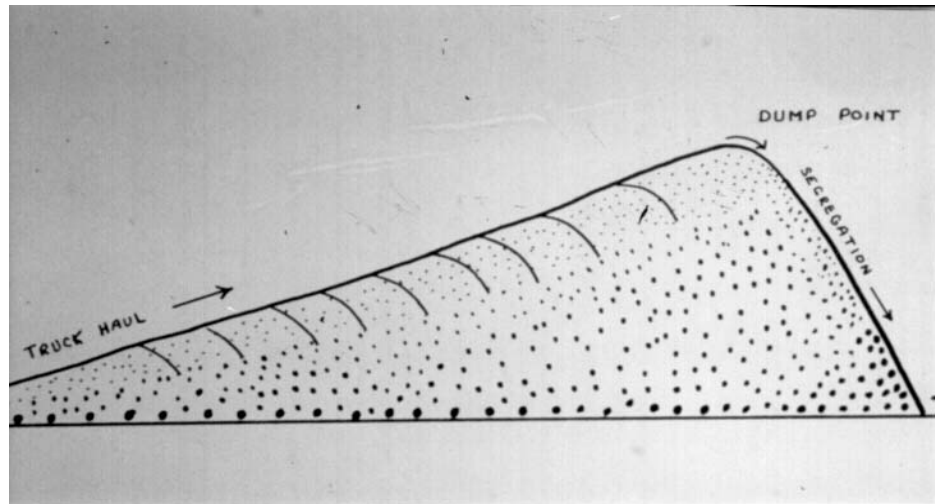


Figure 5-29. Ramp and end dump.

STOCKPILING - GENERAL

It is very important for the producer to write standard operating procedures on building stockpiles for each product and to educate all those involved in their responsibilities in the procedure. Most stockpiling problems are created because of inconsistent management. That procedures must be followed, without exception, should be emphasized to everyone involved. The procedures should become part of the Quality Control Plan Illustrations

at the end of this chapter show the different techniques that may be used for stockpiling and retrieving. The Segregation Index (S.I.) shown with each example is a numerical index where the numbers are associated only with the other techniques and indicate greater segregation severity as they become higher.

DEGRADATION

Degradation or breakdown of the product most often is caused by equipment running on top of the aggregate when it is being stockpiled (as was previously indicated in the example of the layered stockpile). When this occurs the degraded portion of the pile must be discarded before shipping. The difficulty lies in knowing where the "bad" material begins and ends. Extensive sampling and testing in these cases may be needed prior to shipping to determine what product is not good enough to ship. Degradation may also occur during retrieval where some of the lower portion of the pile is carelessly run over with equipment while loading out. A producer must know which products tend to degrade with handling and make appropriate allowances. For example, many stone sands increase in minus No. 200 content each time they are loaded and moved. In some cases old stockpiles can degrade through weathering. Piles two years and older should be rechecked for gradation before shipping and possibly even for mineral quality.



Figure 5-30. Equipment on stockpile.

CONTAMINATION

Contamination is usually the result of carelessness and poor housekeeping. In order to save space, stockpiles of different products are placed close together and as they grow in size they grow together. Equipment also can track dirt or other foreign matter into the product pile area. And, old piles are subject to wind-blown fines over time and should be checked for this before shipping.



Figure 5-31. Comingled stockpiles.

RETRIEVAL

Retrieving material properly from a stockpile is just as important as building the stockpile properly. Truckers often force their way into the loading area, causing the loader operator to load from areas other than the working face. This practice should not be tolerated. Strict procedures for loadout must be written, adhered to, and become routine as part of standard operating procedures. Loading from the outside of an unworked pile for the sake of convenience can very quickly result in a dissatisfied customer.

Cone-shaped stockpiles are the most difficult to approach. Once retrieval has begun, no new material should be added to the pile. To maintain a representative gradation, exactly one-half of the pile should be removed; the edges (coarse) folded into the center (fine); and the entire mass turned over and made into a level pad. The product is then ready for shipping. After shipping the first half of the pile, the procedure should be repeated for the second half. New material must be placed elsewhere in the meantime.

For radial or tent-shaped stockpiles retrieval should begin at the oldest end while new material continues to be placed at the other end. The first entry into a new pile is handled as described above since the beginning of a radial pile is half-conical-shaped. After a face has been established parallel to the stacking conveyor, continued mixing occurs in front of the loadout face by pulling material from the center of the pile and mixing it with the edges. The face should be kept as uniform as possible. At no time should new material be placed at the loadout face.

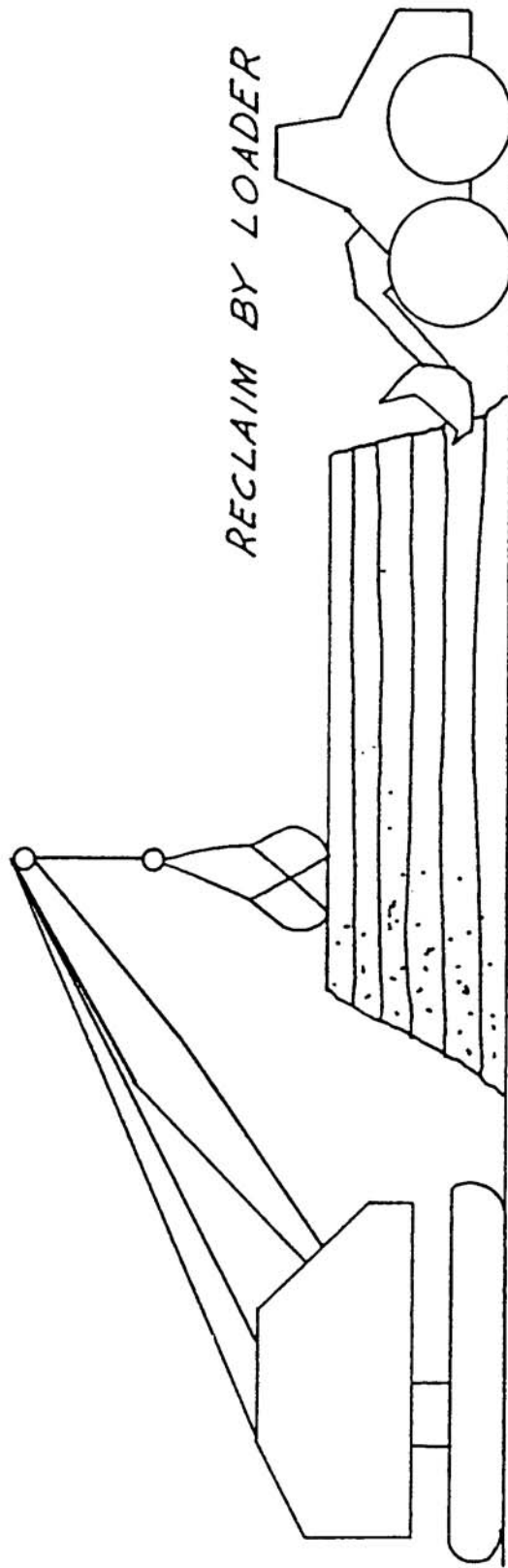
For layered stockpiles more than one loader bucket high, remixing is necessary as the height of the pile and type of the product dictates. For low-profile truck-built stockpiles, probably only minor remixing will be required when encountering the edges.

In retrieving material as well as in building stockpiles a good measure of common sense is necessary. All the effort in creating a consistent product is for naught if care and good practice is not used to keep the product unaltered and consistent up to the point where it leaves the producer's control.



Figure 5-32. Retrieval from stockpile.

STOCKPILE BY CRANE BUCKET



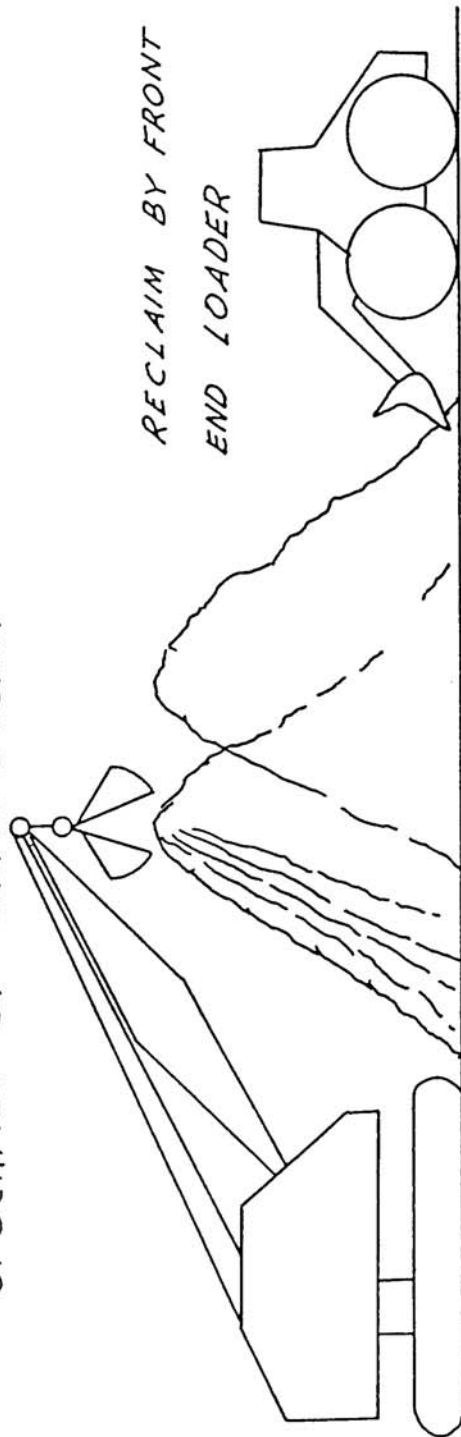
RECLAIM BY LOADER

STOCKPILE METHOD #1

SPREADING AGGREGATE IN THIN LAYERS WITH CRANE BUCKET

BEST METHOD → SEGREGATION INDEX 1.35

STOCKPILE BY CRANE BUCKET



RECLAIM BY FRONT
END LOADER

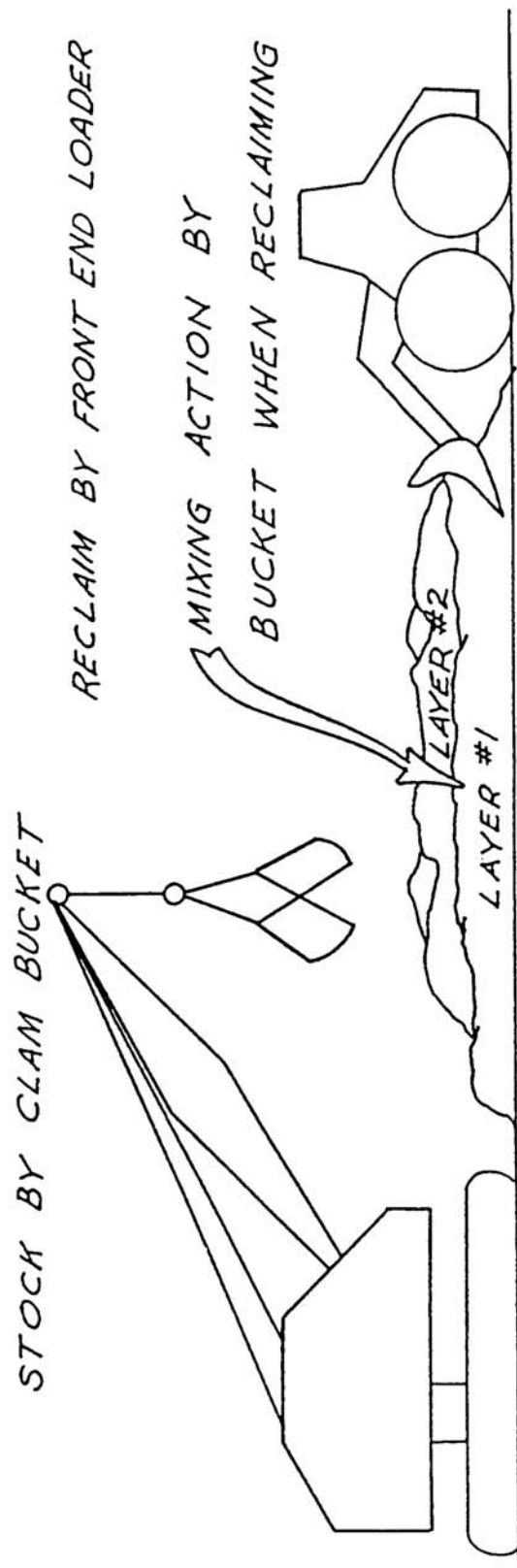
(COARSE GOES TO OUTSIDE OF CONE - FINES TO THE CENTER)
(RECLAIMING BY LOADER REMIXES COARSE AND FINE)

STOCKPILE METHOD #2

TWO CONES (APPROX. 750 TONS) CONSTRUCTED BY CRANE BUCKET

RECLAIM BY FRONT END LOADER

SEGREGATION INDEX - 16.48



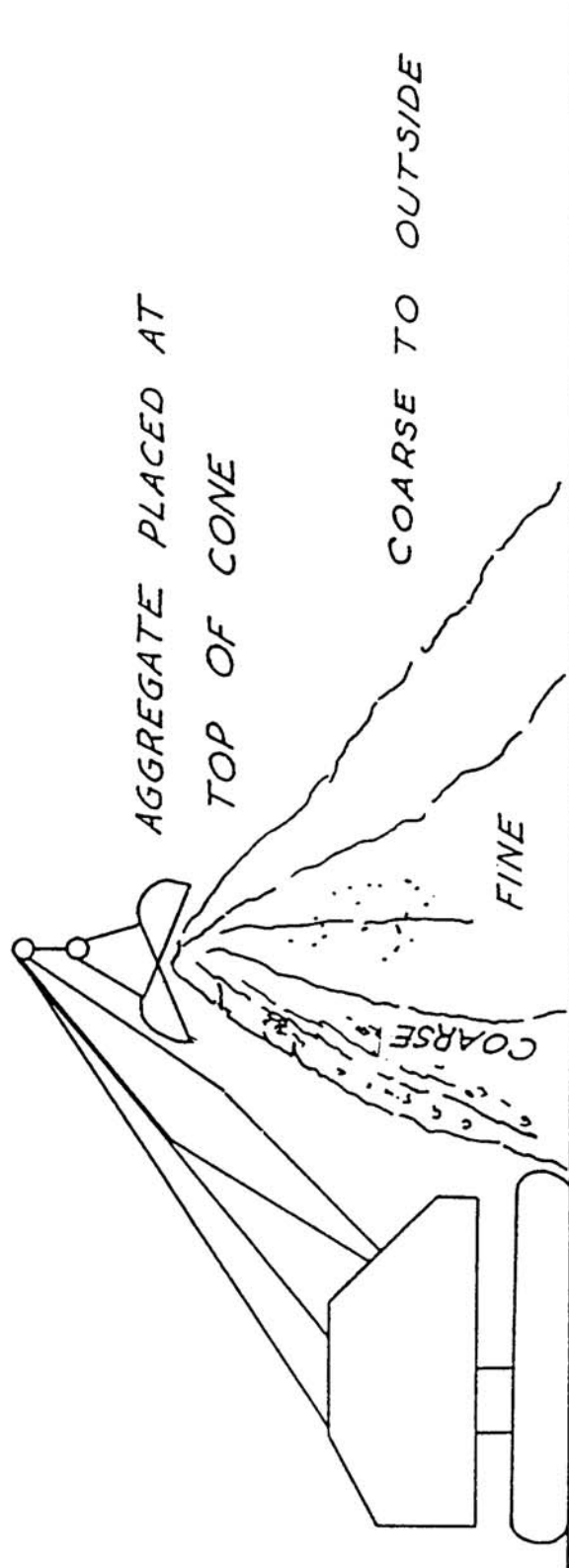
STOCKPILE METHOD #3

FLAT - LAYERED PILE BUILT WITH CLAM BUCKET

RECLAIM WITH FRONT END LOADER

SEGREGATION INDEX - 1.96

STORED AND RECLAIMED
BY CLAM BUCKET

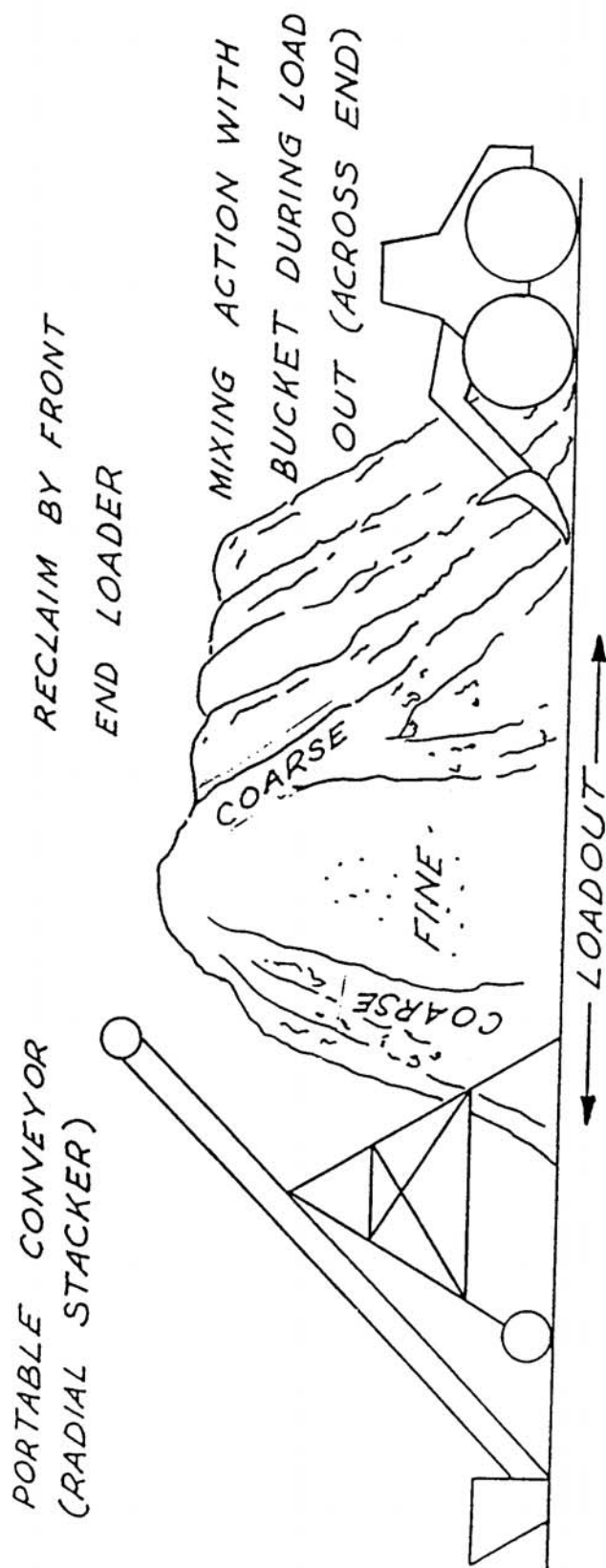


STOCKPILE METHOD #4

SINGLE CONE BUILT WITH CLAM BUCKET (APPROX 1500 TONS)

RECLAIMED BY CLAM BUCKET IN HORIZONTAL LAYERS

SEGREGATION INDEX - 16.86 (WORST METHOD)



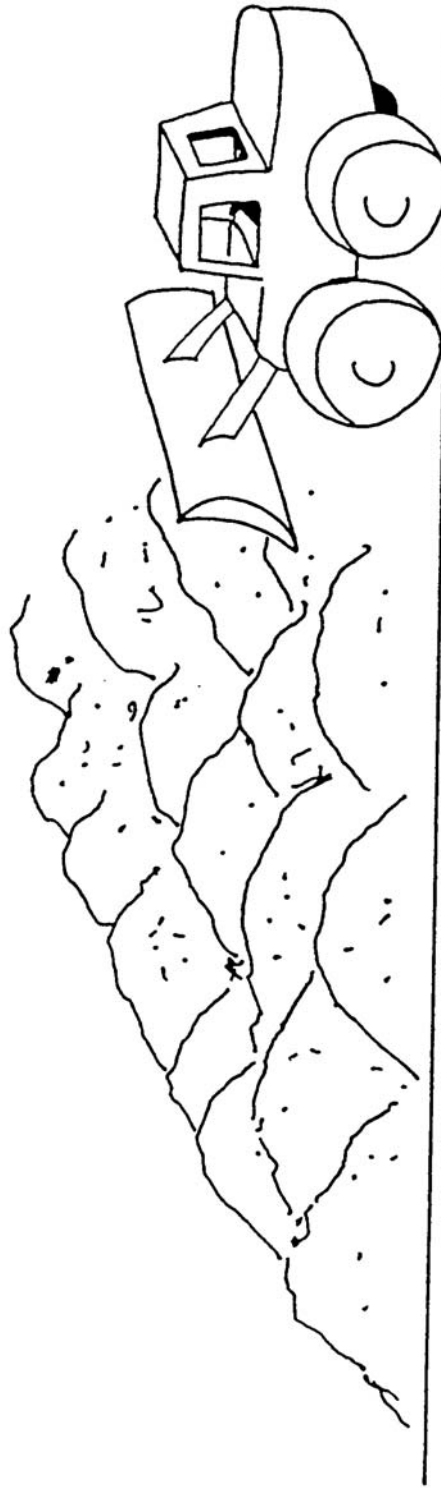
STOCKPILE METHOD #5

TENT SHAPED STOCKPILE - BUILT WITH PORTABLE CONVEYOR
 RECLAIMING BY FRONT END LOADER

SEGREGATION INDEX - 8.10

LIMITING FACTORS
HEIGHT OF LOADER BUCKET
LARGE AREA REQUIRED

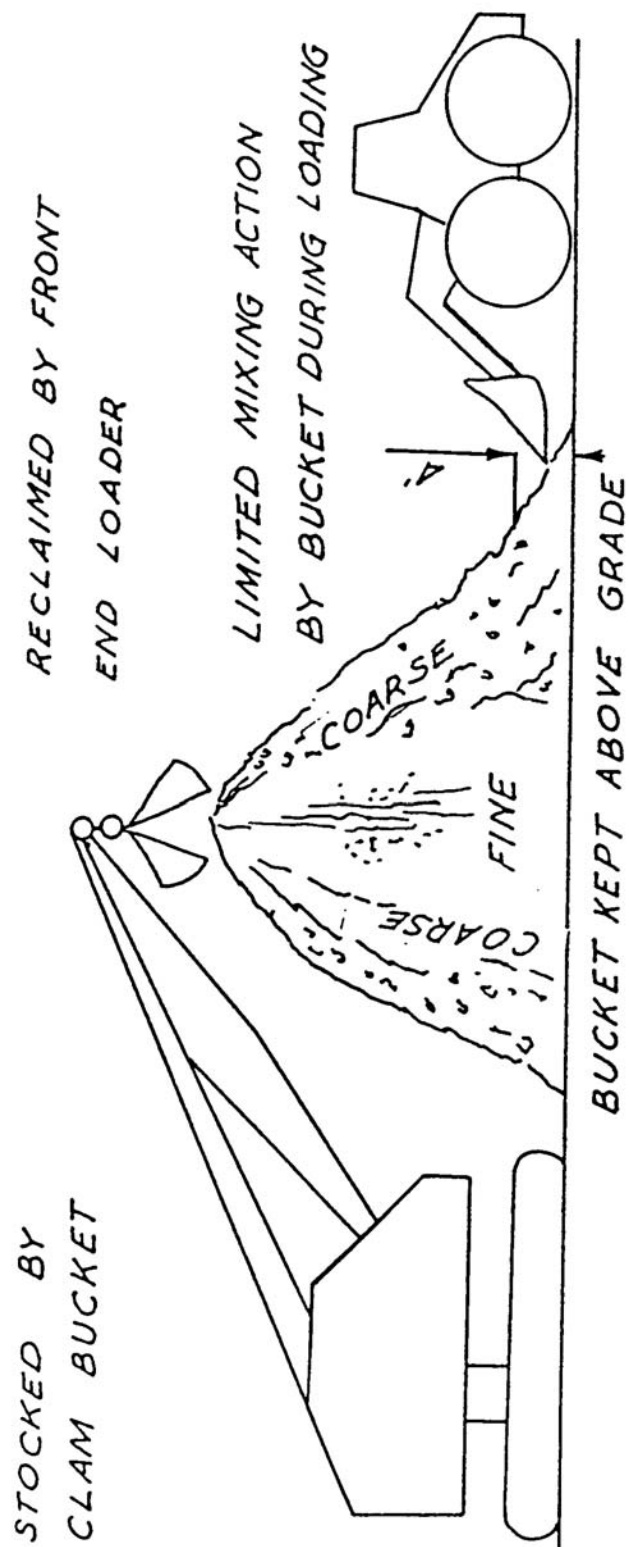
STOCKED AND RECLAIMED
BY FRONT END LOADER



STOCKPILE METHOD #6

FLAT LAYERED CONSTRUCTED BY FRONT END LOADER
RECLAIMED BY FRONT END LOADER

SEGREGATION INDEX - 4.05



STOCKPILE METHOD #7

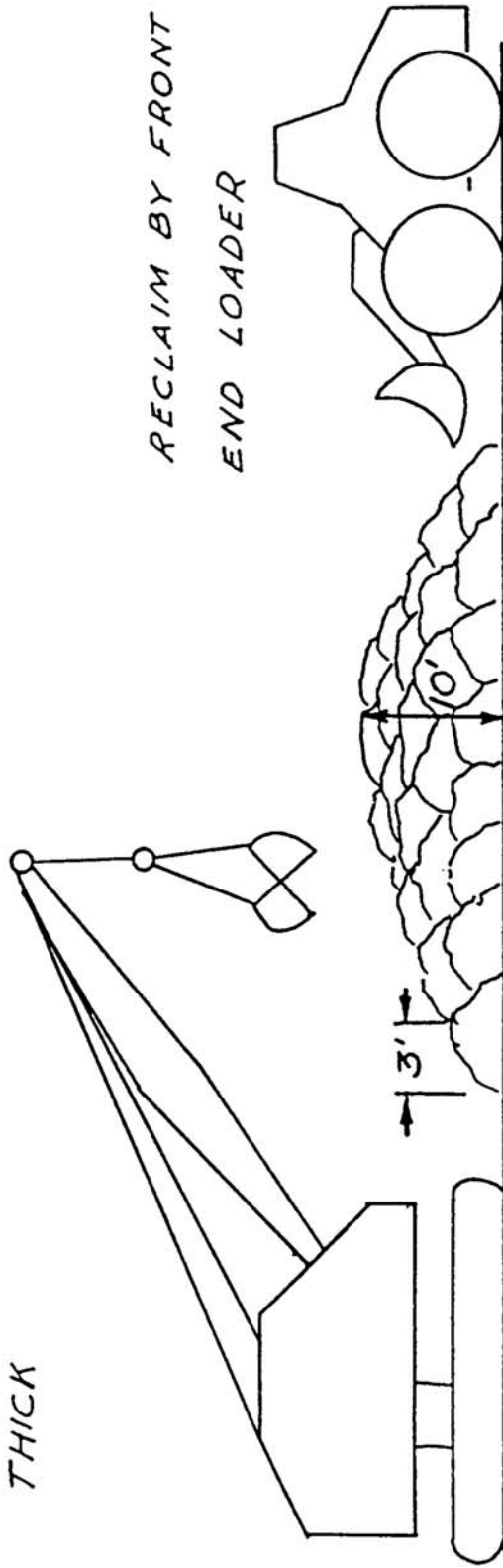
SINGLE CONE - CONSTRUCTED BY CLAM BUCKET

RECLAIMED BY FRONT END LOADER

SEGREGATION INDEX - 13.36

STOCK BY CLAM BUCKET
EACH LAYER ONE BUCKET

THICK



METHOD VERY SLOW AND EXPENSIVE
SET BACK OF 3 FT BETWEEN LAYERS

STOCKPILE METHOD #8

TIERED (BERMED) BY CLAM BUCKET

RECLAIMED BY FRONT END LOADER

SEGREGATION INDEX - 7.37

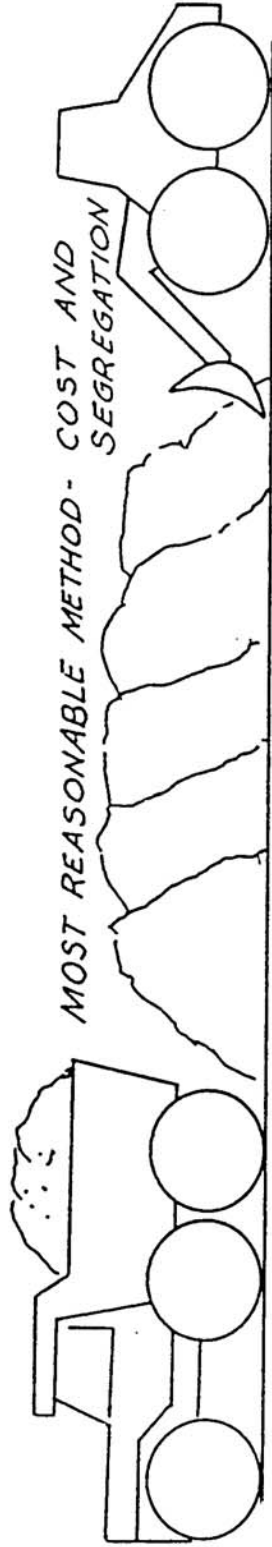
STOCKED BY TRUCK BACKED
INTO SIDE OF PRECEDING PILE

RECLAIMED BY FRONT
END LOADER

THIS METHOD CAN BE TIERED

MIXING ACTION BY

BUCKET DURING LOADING



STOCKPILE METHOD #9

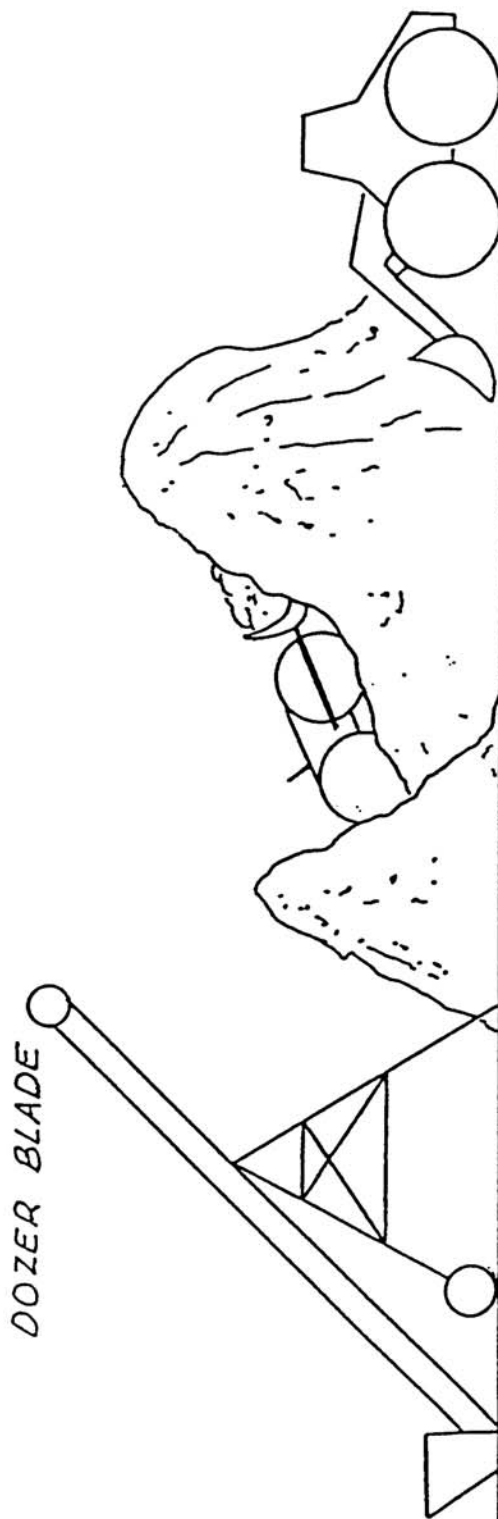
TRUCK DUMP SINGLE LOAD - BACKED AND DUMPED

RECLAIMED BY FRONT END LOADER

SEGREGATION INDEX 2.30

STOCKED BY CONVEYOR BELT
 PUSHED UP BY DOZER
 GOOD MIXING ACTION BY
 DOZER BLADE

RECLAIMED BY FRONT END LOADER
 GOOD MIXING ACTION BY LOADER
 BUCKET DURING RECLAIMING



STOCKPILE METHOD #10

RAMP BUILT WITH PNEUMATIC-TIRED BULLDOZER

RECLAIMED WITH FRONT END LOADER

SEGREGATION INDEX 1.59